

**REMARKS**

Applicants have carefully considered this Application in connection with the Examiner's Action, and respectfully request reconsideration of this Application in view of the above Amendment and the following remarks.

Applicant has amended Claim 1 to incorporate the limitations of Claim 2. Claims 2 and 31 – 32 have been cancelled. Claim 25 is amended to specify that the RuO<sub>2</sub> is deposited directly on the inter-level dielectric substrate. Claim 48 is amended to specify that the a plurality of layers of RuO<sub>2</sub> or Ru deposited on the dielectric material lacks additional elements. Support for these amendments can be found in the specification at pages 5 – 6, where Ru and/or RuO<sub>2</sub>, alone or in combination, is described as replacing the Ta/TaN barrier and the Cu-seed layer, which would normally separate the copper from the dielectric material. Claim 47 is withdrawn.

Pending in this application are Claims 1, 3 – 10, 25 – 29, 33 – 34, and 48.

**I. Claims 1 – 10**

A. 35 U.S.C. §103(a); U.S. Patent No. 6,831,003 to Huang et al. in view of U.S. Patent No. 5,637,533 to Choi

Claims 1 – 10 stand rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 5,618,746 to Huang et al. (“Huang”) in view of U.S. Patent No. 5,637,533 to Choi (“Choi”). The Examiner asserts that Huang discloses the claimed method of controlling copper diffusion through the addition of a layer of Ru and an additional layer as a diffusion stuffer on top of the inter-level dielectric substrate. Although Huang does not disclose depositing copper on an additional layer of RuO<sub>2</sub>, the Examiner asserts that Choi teaches depositing copper on RuO<sub>2</sub>.

Applicant respectfully asserts that the claims as amended are not obvious in view of Huang in combination with Choi. Applicant has amended Claim 1 to include the limitations of Claim 2, which state that multiple layers of Ru and RuO<sub>2</sub> are deposited between the inter-level dielectric substrate and the copper layer. The Examiner asserts that the use of multiple layers of Ru and RuO<sub>2</sub> is obvious in view of Huang and Choi because “mere duplication of the essential working parts of a device involves only routine skill in the art.” See Office Action dated March 22, 2006, page 4.

Applicant respectfully disagrees and asserts that Claim 1 as amended is patentable. Claims 2 – 10, being dependent on Claim 1, are similarly patentable.

First, Huang does not disclose the use of RuO<sub>2</sub> in any layer. Huang does disclose the use of Ru, but there is no mention of using the oxide of Ru. See Huang, col. 6, ll. 32 – 37. Thus, Huang cannot teach the use of alternating layers of Ru and RuO<sub>2</sub>. Furthermore, based on the teachings of Huang, it is not merely routine skill in the art to add duplicating layers to this device. Huang actually teaches away from the use of multiple, repeating layers because Huang makes it clear that adding multiple, repeating layers to an integrated circuit is not analogous to merely duplicating the essential parts of a working device. Stacking additional layers of material on an integrated circuit has a fundamental effect on the properties of the circuit and especially the adhesiveness between the layers. For example, Huang requires that the thickness of the diffusion barrier be controlled to be equal to or greater than particular pore sizes within the dielectric material. See Huang, col. 3, ll. 30 – 53; col. 5, ll. 49 – 52; col. 5, l. 66 – col. 6, l. 2. Huang is concerned with the precise deposition of precise depths of the diffusion barrier. The more layers that must be deposited, the more difficult the calculation of the depth and the more inappropriate that deposition method is for Huang’s purposes. Huang therefore teaches away from the use of multiple repeating layers of Ru and RuO<sub>2</sub>.

Huang also teaches away from the use of multiple repeating layers of Ru and RuO<sub>2</sub> because Huang acknowledges the problem of adhesiveness between the diffusion barrier layers. As discussed in the specification at Page 3, “[s]tructural integrity concerns and adhesion issues of the barrier metal to the new ultra low-k dielectric are often mentioned as accompanying problems.” Huang also teaches the problem of adhesion by suggesting that additional “adhesion promoting” layers should be added in to the diffusion barrier layer even if these layers do not serve as diffusion barrier materials. See Huang, Col. 7, ll. 23 – 29. Thus, Huang clearly teaches that multiple layers of barrier material are disfavored due to adhesion problems.

Choi fails to teach or suggest the use of multiple repeating layers of Ru and RuO<sub>2</sub> because Choi teaches that a layer of RuO<sub>2</sub> is obtained by first implanting O<sub>2</sub> on a Ru layer, then preparing an “ultimate ruthenium oxide layer.” See Choi, col. 2, ll. 34 – 40. The use of the word “ultimate” by Choi clearly teaches that this upper layer of RuO<sub>2</sub> is meant to be the final layer. Choi also states that it includes only a first diffusion barrier metal layer and a second diffusion barrier metal layer. See

Choi, col. 1, ll. 49 – 53. In addition, Choi also teaches that the addition of multiple, repeating layers of barrier material is not analogous to mere duplication of the working parts of a device because the thickness of the resultant barrier material has a direct effect on the difficulties involved in constructing the device. For example, Choi teaches that the amount of O<sub>2</sub> implanted is directly dependent on the thickness of the underlying Ru layer. See Choi, col. 2, ll. 29 – 33. Repeating multiple layers according to the teachings of Choi would be difficult due to the need to recalculate the thickness of each Ru layer and the amount of O<sub>2</sub> needed for each subsequent implantation. Thus, Choi also teaches away from the use of multiple repeating layers of Ru and RuO<sub>2</sub> as claimed in Claim 1.

For these reasons, Claim 1 and its dependent Claims 2 – 10 are patentable over Huang in view of Choi.

**II. Claims 25 – 29**

**A. 35 U.S.C. §102(b); Choi**

Claims 25 and 28 – 29 stand rejected under 35 U.S.C. §102(b) as being anticipated by Choi. Applicants respectfully assert that the claims as amended are not anticipated by Choi. Claim 25 has been amended to specify that the one or more RuO<sub>2</sub> layers is directly deposited on to the inter-level dielectric substrate. By contrast, Choi discloses only the deposition of ruthenium, followed by the heat-treatment of the substrate and the already-deposited ruthenium layers in a chamber containing oxygen in order to create RuO<sub>2</sub>. See Choi, col. 2, ll. 34 – 39. Thus, Choi only discloses the vapor deposition method of obtaining RuO<sub>2</sub> and does not disclose the direct deposition of RuO<sub>2</sub>. For that reason, Claims 25 and 28 – 29 are not anticipated by Choi.

**B. 35 U.S.C. §103(a); Choi in view of the Examiner’s Remark**

Claims 26 – 27 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Choi in view of the Examiner’s remark. The Examiner asserts that Choi discloses depositing an RuO<sub>2</sub> layer on the ILD using a thermal oxidation technique and a physical vapor technique and that the claimed methods of deposition are commonly used. Applicant asserts that Choi does not teach or suggest the direct deposition of layers of RuO<sub>2</sub> onto the ILD, as required by the amended claims, because Choi teaches only the deposition of ruthenium followed by treatment with oxygen. The claimed method

of deposition cannot be considered to be obvious and commonly used in view of Choi because Choi teaches a completely different method that does not involve the direct deposition of RuO<sub>2</sub>. For these reasons, Claim 25, and its dependent Claims 26 – 27 are patentable over Choi in view of the Examiner’s remark.

**III. Claims 31 – 32**

**A. Iwasaki et al.**

Claims 31 – 32 stand rejected under 35 U.S.C. §102(e) as being anticipated by Iwasaki et al. (“Iwasaki”). Applicant has cancelled Claims 31 – 32.

**B. Huang**

Claims 31 – 32 stand rejected under 35 U.S.C. §102(e) as being anticipated by Huang. Applicant has cancelled Claims 31 – 32.

**IV. Claims 33 – 34**

Claims 33 – 34 stand rejected under 35 U.S.C. §102(e) as being anticipated by Iwasaki. The Examiner asserts that Iwasaki discloses the use of Ru and RuO<sub>2</sub> as a diffusion barrier. Applicant respectfully asserts that Iwasaki discloses the use of a barrier metal composite to prevent diffusion and does not disclose the use of Ru and RuO<sub>2</sub> alone, or without an added element. Thus, claims 33 – 34, which pertain to the use of Ru and RuO<sub>2</sub> alone, rather than a composite metal layer, as a diffusion barrier, are not anticipated by Iwasaki.

**V. Independent Claim 47**

Applicant acknowledges the withdrawal of Claim 47.

**VI. Independent Claim 48**

Claim 48 stands rejected under 35 U.S.C. §102(e) as being anticipated by Iwasaki. The Examiner asserts that Iwasaki discloses the use of a plurality of layers of Ru and RuO<sub>2</sub> as a diffusion barrier. Claim 48 as amended states that the plurality of layers of Ru and RuO<sub>2</sub> are without additional elements. Applicant respectfully asserts that Iwasaki discloses the use of a barrier metal composite to prevent diffusion and does not disclose the use of Ru and RuO<sub>2</sub> alone, or without an

added element. Thus, claim 48, which pertain to the use of Ru and RuO<sub>2</sub> alone, rather than a composite metal layer, as a diffusion barrier, are not anticipated by Iwasaki.

**VII. Conclusion**

Applicants respectfully submit that, in light of the foregoing comments, Claims 1, 3 – 10, 25 – 29, 33 – 34, and 48 are in condition for allowance. A Notice of Allowance is therefore requested.

If the Examiner has any other matters which pertain to this Application, the Examiner is encouraged to contact the undersigned to resolve these matters by Examiner's Amendment where possible.

Respectfully submitted,

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